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PARENTS OF ADOLESCENTS

A Thesis

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In Partial Fulfillment

of the Requirements for the Degree

Master

in

Public Health

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by

Daniel G. Burnett

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DEDICATION

This thesis is dedicated to my beautiful, loving, kind, intelligent, supportive, and industrious wife, [redacted] Her love and support have been the greatest miracles I've been blessed with in my life.

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CHAPTER I

BACKGROUND

Obesity is widely recognized as a significant and problematic epidemic in the United States (U.S.). Although some controversy exists as to the precise proportions different phenomena have played in creating this epidemic, clearly lack of adequate physical activity is a critical component. The most-recognized public health standard for minimally adequate or sufficient physical activity calls for at least 30 minutes of at least moderate-intensity activity on most, preferably all, days of the week, which is usually interpreted as at least 5 days/week (Pate et al., 1995). The Centers for Disease Control (CDC) recently reported that, according to Behavioral Risk Factor Surveillance Survey data, the majority of adults were still not regularly physically active to these standards in 2000 (26.2%) or 2001 (45.4%), even with attempting to include updated lifestyle activity in the definitions of regular physical activity in 2001 (CDC, 2003). In the 1996 Surgeon General's report, "Physical Activity and Health," some of the many benefits known to be derived from regular physical activity were outlined, including reduced risks of dying prematurely or dying from cardiovascular diseases (U.S. Department of Health and Human Services [USDHHS], 1996). Physical activity reduced the risks of developing diabetes, high blood pressure, and colon cancer. In addition, regular physical activity reduced feelings of depression and anxiety, helped control weight, and contributed to general psychological well-being.

The USDHHS (2002) recently listed the benefits of physical activity and the problems associated with physical inactivity affecting tens, if not hundreds, of millions of people in the U.S. The Department described the profound economic consequences, totaling hundreds of billions of dollars for the U.S., and noted the myriad of physical and mental health benefits associated with physical activity and the role physical activity plays in maintaining energy balance, and gave a short discussion of the overweight and obesity epidemic. They also discussed the associated risks of not maintaining a healthy body weight, called on communities to develop environments that encouraged walking, bicycling, and other exercise, and called on individuals to commit to an active lifestyle.

Peters (2002) discussed the different factors contributing to the "obesigenic environment" in America as well as the rest of the world. In addition to food factors, he recognized an important role of the environment. Factors he credited for this unhealthy situation included the many ways activity has been engineered out of environments as technological advancements have occurred. In years past, physical activity was required to secure and prepare food, water and shelter. Nowadays, however, with automobile-based transportation systems, "unfriendly" physical activity community designs, decreased physical education classes in schools, and increased reliance on other technologies, the need for physical activity to accomplish the necessary tasks of daily life has diminished dramatically.

Even with these clear and present dangers to our health from inactivity and aggressive efforts to promote the importance of adequate levels of physical activity in the 1980s and 1990s, the CDC (2001) has noted that only about one fourth of U.S. adults met recommended levels of physical activity. Furthermore, the reported levels remained relatively constant from 1990 to 1998.

In a foreword to the *American Journal of Preventive Medicine's* supplement derived from a meeting at the Cooper Institute, held October 4–6, 2001, Powell, Bricker, and Blair (2002) urged researchers to look for ways to increase physical activity by means other than individual-level behavioral modification interventions that have been extensively used in the past. Powell et al. noted the socio-ecologic model and the disciplines of urban planning and transportation as promising potential new additions to the public health armamentarium that might well promote better successes in treating physical inactivity. With the lack of success of efforts over the last 20 years in reversing this phenomenon, new tools promising better public health efficacy warrant further study. One approach to the problem considered in this study was exploring how different aspects of the physical environment might influence physical activity behavior.

Statement of the Problem

Identifying environmental correlates of physical activity that could, if disseminated widely and made easily available to people, lead to higher levels of physical activity has promising public health impact. This study explored whether self-reported environmental variables were correlated with self-reported physical activity levels.

Purpose of the Study

This study was designed to determine if relatively inexpensive self-reported measures of the environment were associated with physical activity. There has been contradictory evidence as to whether self-report measures can predict physical activity (Sallis & Owen, 1999; Trost, Owen, Bauman, Sallis, & Brown, 2002), and much of the research is now pursuing more objective measures of the environment. However, there is a continuing need to identify tools and questions that can elicit what parts of the environment and perceptions of the environment might adequately promote physical activity and warrant interventions and policies for change.

Hypotheses

The specific hypotheses examined in this study were whether self-reported proximity to, and other characteristics of, different environmental variables—including neighborhood parks, recreation centers, and gyms, streets and aesthetics, and sidewalks—predicted a higher likelihood of adequate and higher levels of physical activity in the parents of adolescents involved in a related intervention adjusting for significant confounders.

Theoretical Basis

This study was designed to further evaluate the Ecological Models. These models suggest that behaviors are influenced by intrapersonal, social, cultural, and physical environmental variables as well as public policy (Sallis & Owen, 1996). While Sallis and Owen noted that multiple dimensions of influence are present for many behaviors and that physical environments may directly influence behaviors, at least one study by Sallis et al. (1989) of perceived self-reported environmental variables did not seem to predict physical activity levels. Another study by Sallis et al. (1990), however, noted that perceived self-reported environmental variables may not actually correspond well with direct objective measures of the environment, and these objective measures do, in fact, explain a significant amount of the variation in subjects' physical activity levels.

There have been many studies, meta analyses, and reviews of the literature that have indicated support for this approach to the study of physical activity determinants

(Dannenberg, Keller, Wilson & Castelli, 1989; Disman, Sallis, & Orenstein, 1985; Frumkin, 2003; Jackson, 2003; Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997; Sallis & Owen, 1999; Trost, Owen, et al., 2002), but there have also been studies showing the difficulty demonstrating *which* environmental correlates truly predict physical activity (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Cervero & Duncan, 2003; Giles-Corti & Donovan, 2002; Sallis et al., 1997), with many hypothesized associations being either weak or non-existent.

Basic Assumptions

The first assumption of this study was that people's perceptions or self-reports of the environment accurately reflected their true environment. Yet there is literature to suggest this is not always true (Kirtland et al., 2003; Sallis & Owen, 1996). However, even if people's perceptions did not accurately reflect their environment, it is possible that perceived environment could be important in predicting physical activity and future interventions might need to focus on changing people's perceptions of the environment rather than the actual environment.

The second assumption was that the International Physical Activity Questionnaire (IPAQ) adequately and validly reflected levels of physical activity. A recent 12-country, comprehensive review by Craig et al. (2003) of the IPAQ's reliability and validity determined that it had acceptable measurement qualities and was at least as good as other established self-report instruments. They felt it was reasonable to use IPAQ for adults in many different settings to evaluate physical activity.

CHAPTER II

REVIEW OF THE LITERATURE

Almost 20 years ago, Dishman et al. (1985) reviewed the determinants of physical activity and exercise and noted some environmental correlates, including access to facilities among a myriad of more traditionally explored, mostly individual-based predictors. Other early work, derived from the Framingham study by Dannenberg et al. (1989), supported the link between the physical environment and physical activity levels. Dannenberg and colleagues discovered a substantial seasonal variation in physical activity, noting common outdoor activities were engaged in significantly more frequently during the summer than during the winter.

Sallis et al. (1990) also noted that among San Diego residents, those who exercised regularly lived in environments with a statistically greater density of paid exercise facilities, even after controlling for age, education, and income. However, no similar association was noted between physical activity and free recreational facilities such as public parks. Other early work by Baranowski, Thompson, DuRant, Baranowski, and Puhl (1993) noticed children were consistently more physically active outside and during different seasons, suggesting environmental characteristics played a role.

Linenger, Chesson, and Nice (1991) documented a community-wide prospective intervention where cycling trails were constructed, running paths were marked, new equipment was installed in gyms, and walking and cycling clubs were organized on a San Diego Naval Air Station. After 1 year, improvements in overall fitness—as measured by running times, percentage of body fat, and numbers of sit-ups and pull-ups performed—were significantly greater among 1,600 personnel on the naval air station than among two other comparison groups of Navy personnel.

Researchers have also reviewed transportation, urban design, and planning literatures to gain a perspective from outside the behavioral sciences. Saelens, Sallis, and Frank (2003) found strong evidence from many reviewed studies that people who lived in communities with higher density, better connectivity, and mixed-land use had higher rates of walking and

bicycling for daily activities like commuting to work or school or running errands. The researchers called on behavioral scientists to recognize the value of this already examined work to collaborate and use the information to help develop environments likely to improve physical activity levels in populations. They also felt activities like walking and biking, being potentially useful for utilitarian pursuits, may be more influenced by the physical environment.

Saelens, Sallis, and Frank (2003) also reviewed four correlational studies from the transportation and urban design literature that tried to control for potential socio-demographic confounders. From those studies, population density was recognized to be the most consistent predictor of walking trips. Employment density, land-use mix, and walking/cycling infrastructure, as well as elements such as bike paths, sidewalk continuity, good lighting, were suggested as potentially important correlates. While recognizing the limitations of such quasi-experimental designs, the researchers also noted that random assignment of residents to neighborhoods is not terribly feasible, and waiting for such definitive data will slow the progress toward recognition of true causality of different environmental variables.

It may be that more active people choose more walkable communities. Studies of pre- and post-measurements after changing of environmental variables, as discussed in the previously mentioned Navy study by Linenger et al. (1991), have the potential to help clarify causality issues and should be pursued.

After reviewing many studies, Saelens, Sallis, and Frank (2003) estimated a mean difference between high- and low-walkable neighborhoods of 1–2 walk trips per week or 15–30 minutes more walking per week. Although relatively modest on an individual level, the population health effects could be profound, and authors called for further pursuit of these intriguing data. They recognized the power of these interventions could be dramatic, especially in maintenance of physical activity, where other behaviorally oriented approaches to encourage physical activity had fallen short.

Trost, Owen, et al. (2002) updated a previous comprehensive review by Sallis and Owen (1999) of the correlates of adults' participation in physical activity. Of particular interest for Trost, Owen, and colleagues was how the perspective changed subtly: perceived access to facilities showed a weak or mixed evidence of positive association with physical

activity compared to the previous interpretation by Sallis and Owen (1999). The earlier Sallis and Owen review indicated that such perceived variables showed a repeated lack of association with physical activity. Age and gender were recognized as continuing to be the most consistent correlates of physical activity and should be controlled for in analyses of other correlates. Trost, Owen and colleagues, however, noted 10 new environmental variables had been evaluated for their effect on physical activity and applauded the progress in increasingly examining these correlations. They also called for more information on how pregnancy, childbirth, and parenting may act as barriers for physical activity.

Further evidence supporting Ecological Models was provided by Powell, Martin, and Chowdhury (2003) when they added questions about safe and convenient places to walk to the Georgia Behavioral Risk Factor Surveillance System random-digit-dialed telephone survey of health-related behaviors. They discovered that respondents self-reported a clear relationship between the convenience of their walking place and the proportion of the respondents who were meeting current physical activity recommendations. Respondents who were able to walk to their most convenient walking place in < 10 minutes were most likely to be active.

Saelens, Sallis, Black, and Chen (2003) also recently compared differences in "walkability" between two neighborhoods in San Diego. The more walkable neighborhood had more mixed-use (residential and commercial) buildings and a more grid-like street pattern than the less walkable neighborhood. Further, the less walkable neighborhood was comprised primarily of single family homes and contained more cul-de-sacs. Residents in the more walkable neighborhood averaged 52 minutes more moderate-intensity physical activity per week than residents in the less walkable neighborhood. Likewise, a higher percentage of the residents in the less walkable neighborhood were overweight.

Also supporting Ecological Models, Frumkin (2003) has suggested that the "quality" of a place could influence how likely the place is to be a healthy place for people. The physical environment is just one potential component of this concept. Aesthetics, spiritual and emotional associations, as well as the ability to gain social capital from the environment also play roles, but the built, physical environment clearly is an important part of creating a healthy environment. An example cited by Frumkin was how most modern buildings of more than two or three floors have attractive, elaborate elevators with hidden dingy staircases.

Would people be more likely to use the stairs if elegant attractive staircases were again more prominent? Urban sprawl was also characterized as unhealthy, and its principal features were identified as low residential and employment density, distinct land uses (little mixed use), low connectivity, weak and dispersed activity centers and downtowns, and heavy reliance on cars with few alternatives. Frumkin also called for enhanced research into the health implications of places as well as application of the findings.

In 2003, Jackson noted that how we build our current and future environment has great potential to address many of the most pressing public health problems of our time, including cardiovascular disease, obesity, diabetes, asthma, injury, depression, violence, and social inequities. Some of our current environments are relics of zoning laws from a time when public health required homes be separated from commercial enterprises, like abattoirs and tanneries, to avoid odors and toxic emissions. Likewise, laws at one time tried to avoid higher density communities to avoid the rapid spread of tuberculosis and other infectious diseases. Jackson also noted that longer commutes, traffic delays, and costs associated with maintaining vehicles are all sequelae of lower density land use. Along the same lines, children are less likely to walk to school because of distances involved and safety issues, contributing to the childhood obesity epidemic. While changes in these environments will not happen quickly, they will have the potential for profound benefit to future generations if we work hard now to make them happen.

Giles-Corti and Donovan (2003) used objective measures of the environment and self-report of physical activity to determine correlates of walking. They discovered that few (17.2%) of their Perth, Australia subjects were walking enough to meet Australian-recommended guidelines ($\geq$ 12 sessions of walking in the previous 2 weeks, totaling $\geq$ 360 minutes). Giles-Corti and Donovan also discovered that those who walked for both recreation and transportation were much more likely to be active at recommended guidelines (78.2%), and found significant relationships between individual determinants, social environmental determinants (primarily whether one had $\geq$ 1 significant others who exercised with respondent weekly over the last 3 months, and whether they owned a dog), and physical environmental determinants. The physical environmental correlates that approached statistical significance or were statistically significant involved <u>assessments of</u> the appeal of

the environment by objectively measuring traffic and trees as well as access to attractive public open space.

Although only an ecological observation, Pucher and Dijkstra (2003) noted several European countries, especially the Netherlands and Germany, have safer, more accessible sidewalks for walking and safer, more plentiful paths and roads for bicycles than the U.S. They further noted that these European countries have higher levels of walking and cycling for daily travel and far lower rates of obesity. The Netherlands' obesity rate is only one third the U.S. rate and Germany's is only half the U.S. rate.

Also from overseas, a recent univariate analysis by Bonnefoy, Braubach, Moissonier, Monolbaev, and Robbel (2003) of a broader survey on housing and health in Europe noted that among adults in Forli, Italy persons who lived < 100 meters from a park were more likely to engage in regularly exercise (32.7% vs. 26.4%), less likely to never exercise (21.8% vs. 24.7%), and less likely to have a body mass index (BMI) > 25.

Kahn et al. (2002) reported on the *Guide to Community Preventive Service*'s methods assessing the effectiveness of different approaches to increasing physical activity. The researchers found 12 studies they considered as relevant for evaluating the effectiveness of either creating or improving access to physical activity, combined with informational and/or educational outreach programs. Of these studies, 10 had adequate study design to be included in their analysis. Overall, Kahn and colleagues thought the preponderance of the evidence suggested that such interventions were effective ways to increase physical activity.

However, not all of the data strongly supports theorized relationships between physical activity-promoting environmental variables and physical activity. In one study, Sallis et al. (1997) looked at 43 self-reported variables reflecting the environment. In the initial analyses, home equipment and convenient facilities scales were correlated with self-reported physical activity. However, after adjusting for socioeconomic status, only home equipment was associated with physical activity (strength exercises). None of the variables predicted variance in walking, and none of the environmental variables predicted large amounts of the variance in physical activities in any of the analyses. Some potential explanations for why more striking effects of the environment on physical activity were not noted included: homogenous population of college students, self-reported measures may be inaccurate, or the wrong self-report measures may have been examined. The authors called

for more research to determine what the objective is and what self-reported environmental measures truly explain variance in physical activity.

In reviewing 16 studies that examined the relationship between subjectively reported environmental variables and activity levels, Humpel, Owen, and Leslie (2002) found quite a mixed bag. Many of the studies they reviewed hypothesized that physical activity-promoting environmental variables had little or no effect, while a few studies (notably convenient home exercise equipment) seemed to show some association with physical activity. Four studies with objectively measured environmental variables seemed somewhat more likely to show significant associations with main outcome physical activity variables, but again had mixed and sometimes unexpected negative results. Overall, Humpel et al. thought the pattern of findings supported a conclusion that the majority of variables related to convenience and access in the environment to facilities were associated with increased physical activity, but the evidence did not overwhelmingly support that many aspects of the environment promoted physical activity.

Likewise researchers in San Francisco noted urban/built environmental characteristics in the San Francisco Bay area had relatively modest, and often statistically insignificant, associations with people's likelihood to bicycle or walk. Cervero and Duncan (2003) noted far stronger effects of topography, darkness, and rainfall in predicting whether people walked or biked instead of used a car. Demographic factors also appeared far more important in their predictive models. The researchers did acknowledge that the uniquely hilly topography of San Francisco might not make these findings generalizeable, and that their built-environment variables may not have fully captured the many nuances of built environments. However, less controllable environmental factors and demographic factors were more predictive than built environmental variables, which might be amenable to public health interventions.

Other reviewers (Bauman et al., 2002; Sallis & Owen, 1996) have felt actual access to facilities was weakly associated or showed mixed results in assessments of associations with physical activity. Their syntheses of the literature on self-report data were that studies showed repeated lack of association between perceived access to facilities and physical activity.

Another example of equivocal evidence for Ecological Models' predictive abilities came from Australian researchers who sought to evaluate the relative influences of

individual, social, and physical environmental variables on physical activity. Although Giles-Corti and Donovan (2002) found some support for the concept that spatial access is associated with more physical activity, especially with regard to larger public facilities, they found composite measures reflecting individual and social variables to be more predictive than physical environmental variables. The authors felt their data perhaps showed that having adequate physical access to physical activity-promoting resources was a necessary, but not sufficient driver of physical activity for their population. Perhaps supportive physical environments must be supplemented by/with individual and social supports and interventions to increase physical activity.

Other researchers concerned with the potential weaknesses of self-report data on the environment have endeavored to assess the reliability and validity of self-report measures of the environment compared to objectively measured geographic information systems' (GIS) evaluations of environmental variables. Kirtland et al. (2003) found generally low-to-moderate agreement between the self-reported neighborhood and community variables and the objectively measured variables. They also found that active respondents had the highest agreement between self-report and GIS variables for access to public recreational facilities and insufficiently active participants' self-reported geographical assessments were more closely aligned on perceived safety or likelihood of crime in recreation facilities.

Given the sometimes contradictory support of the evidence for the Ecological Models, as well as the uncertainty regarding whether or not self-report data is able to adequately predict physical activity, the current study attempted to gather more evidence either supporting or refuting the general concept as well as assessing whether these specific self-report evaluations of the environment could be valuable in future investigations of the models.

CHAPTER III

METHODS

This chapter describes the study design, study population, method of data collection, and means of statistical analysis. Conducted in San Diego, California during 2003–2004, the study examined data collected from 2001–2002 and focused on parents' self-report of their physical activity level and their physical environment.

Study Design

This study was a cross-sectional analysis of data previously collected as part of the Patient-centered Assessment and Counseling for Exercise and Nutrition (PACE) project intervention for adolescents. Parents of adolescents involved in the intervention study were surveyed for self-reported measures of proximity to and other characteristics of environmental variables derived from previous work by others (Saelens, Sallis, Black et al., 2003; Sallis et al., 1997). These data were analyzed to see if they predicted the parents' physical activity, as self-reported on the IPAQ instrument at the beginning of the adolescent study.

Study Population

Participants for the study were recruited between May 2001 and June 2002. Adolescent participants were recruited through primary care practices in San Diego County. Forty-five primary care physicians from six clinic sites in San Diego County, including four Kaiser Permanente sites, agreed to participate in the study.

Phone contact was made by trained study recruiters with a total of 3,366 households. Inclusion criteria for the adolescent participants included being between 11 and 15 years old, in good general health, able to read and speak English, and able to obtain parental consent (obtained in parents' primary language). Adolescents were excluded from the intervention if they had an eating disorder, diabetes, pregnancy, or cardiovascular or musculoskeletal

problem that would limit physical activity recommendations. Foster care children were also excluded due to anticipated difficulties obtaining follow-up measures.

From the 3,366 households contacted by phone, 462 were wrong numbers, 301 did not meet all of the study inclusion criteria, 1,124 attempts resulted in refusals by either the parent or the child, and 447 neither directly refused nor gave full agreement to participate in the study; they were excluded after an inability to reach a household member after eight attempts following the last contact. In 1,032 cases, both parent and child agreed to participate and appeared eligible to participate. Of those, 153 never completed an initial visit to the PACE office to sign forms and be randomized. Therefore, a total of 879 adolescents were ultimately randomized into the intervention study.

At the adolescent's baseline visit, the parent accompanying the adolescent was asked to also complete the self-report measures of physical activity and their environment used in this study. Of the 879 parents of the adolescents, all 879 agreed to complete the self-report measures and were included in the study.

Data Collection

Data was acquired from self-report questionnaires. The questions used for collection of environmental variables (the independent or predictor variables in the models), as discussed above, were developed by Dr. Sallis based on his and others' earlier work (Saelens, Sallis, Black et al., 2003; Sallis et al., 1997). Questions included questions how long it would take the participant to walk to their nearest park, recreation center, or gym or fitness center (coded as 1–5 min = 1, 6–10 min = 2, 11–20 min = 3, 21–30 min = 4, or $\geq$ 31 min = 5, as in Appendix A).

Questions were also designed to assess the pleasantness and safety of walking and bicycling in the participants' neighborhood, as well as about the general attractiveness and aesthetics of the neighborhood surroundings. Questions included statements such as: "The streets in my neighborhood are hilly, making my neighborhood difficult to walk or bicycle in"; or "There are trees along the streets in my neighborhood." Respondents were asked to respond to these on a Likert scale, which had: 1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, and 4 = strongly agree. Variables were coded as 1 to 4. Exploratory

factor analysis was then used to assure composite averages used in the statistical models from several of these questions were assessing similar constructs (see Appendix B).

Self-reported demographic information (sex, age, and educational level) was also obtained and assessed for univariate relationships with physical activity. This information was used to adjust any models in which it significantly changed or confounded primary relationships.

For this study, questions from the recently validated IPAQ (Craig et al., 2003) were used to collect participant's self-reported activity level and thereby the outcome variables for the study (see Appendix C). At the time of this writing, the short form with the questions used in the study was also available at www.ipaq.ki.se (IPAQ Committee, 2004), along with suggested data processing and cleaning rules. The suggested rules for cleaning and processing of the data were followed in this study with minimal changes.

Time was converted from hours and minutes into minutes. To ensure that responses given in minutes were not entered into the hours column by mistake during self-completion or during data entry process, values of 15, 30, 45, 60, and 90 in the hours column were converted to 15, 30, 45, 60, and 90 minutes, respectively, in the minutes column. Time was converted to daily time, and then daily time was converted to MET-minutes/week (MET-min/week) by multiplying daily time in minutes by the number of days/week the person exercised. Any daily values for activity which were < 10 minutes were recoded as 0 (zero), as the IPAQ committee felt the scientific evidence indicates that episodes or bouts of at least 10 minutes are required to achieve health benefits.

The IPAQ committee also recommended removing from analysis any case that had responses of "don't know" and/or "refused" or when data were missing in any of the areas on the form where walking, moderate, or vigorous days or minutes were recorded. For the current study, it was noted that such an overly conservative way to approach the data would have led to discarding information from 624 out of the 878 participants of the study. Participants sometimes circled the word "none" on the form, sometimes left the activity blank, and sometimes put "0" for days of an activity type. Therefore, all of these responses were transformed to "0" unless all of the information for physical activity was missing, which occurred with 23 participants whose data were not used. This was considered an

appropriate and conservative way to approach the data, given that assuming a value of "0" did not cause an overestimation of any physical activity data.

Data values were also truncated, according to IPAQ recommendations, to exclude unreasonably high data. All walking, moderate, and vigorous time variables that totaled ≥ 16 hours were excluded from the analysis. All walking, moderate, and vigorous time variables > 2 hours or 120 minutes were re-coded to be equal to 120 minutes in a new variable, permitting a maximum of 14 hours of activity in a week to be reported for each category of physical activity. This rule had an important effect on the dichotomous category of "highly active" used in some of the analyses. Otherwise, an individual walking 10 minutes/day on 6 days of the week, but then exercising huge hours 1 day/week could be coded as "highly active," although this behavior pattern is unlikely to be as healthful as what the category was designed to represent. The truncation rules also produced lower, and anticipated more conservative and more valid values of the continuous measure, MET-min/week than would have been reported otherwise.

For continuous/linear models and analyses, the total MET-min/week was calculated by summing the following three formulae:

1. Walking MET-min/week = 3.3 * walking min * walking 'days'
2. Moderate MET-min/week = 4.0 * moderate-intensity activity min * moderate days
3. Vigorous MET-min/week = 8.0 * vigorous-intensity activity min * vigorous intensity days.

For dichotomous analyses, "sufficiently active" persons were described as those who met any one of the following three criteria:

1. ≥ 3 days of vigorous activity of at least 20 minutes/day, or
2. ≥ 5 days of moderate-intensity activity or walking of at least 30 minutes/day, or
3. ≥ 5 days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum cumulative total activity level of at least 600 MET-min/week.

Dichotomized "highly active" persons were described as those who met either of the following two criteria: (a) vigorous-intensity activity on at least 3 days and accumulating at least 1,500 MET-min/week or (b) ≥ 7 days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 1,500 MET-

min/week. Theoretically, a person could have 7 days of each activity, so summing all three could lead to > 7 days of total activity.

Additionally for this study, a (non-IPAQ) dichotomous variable describing a "walker" was defined as a sufficiently active person who walked for 5 or more days/week for ≥ 30 min/day to try to capture those meeting the minimum intensity standards for physical activity recommended by public health authorities (Pate et al., 1995). For this study, it was thought that this lower intensity exercising subset of the IPAQ-defined sufficiently active participants' physical activity levels might be more influenced by environmental variables such as parks and sidewalks, which might especially appeal to walkers.

Statistical Analysis

Data cleaning, recoding, and statistical analyses of univariate associations between the park, recreation center, and gym proximity variables and continuous physical activity (MET-min/week) were carried out using SPSS 12.0 for Windows (SPSS, Inc., Chicago IL, 2003). Likewise, composite predictor variables from the other environmental questions were assessed via principal component extraction factor analysis in SPSS 12.0 with varimax orthogonal rotation to assure measurement of the same construct. Cronbach's alpha was calculated to assess the relatedness of included questions. Scores were then averaged for these composite measures and analyzed for evidence of univariate associations with MET-min/week within SPSS. All significant correlates were then included in multivariate linear models, which were then further assessed for interactions and then confounding by the other potential covariates/confounders if these variables were not already in the models by virtue of being univariately related to MET-min/week. Any potential confounders that altered univariately related variables' parameter coefficients in the model by ≥ 15% were included in the final multivariable model.

Likewise, univariate logistic regression analyses were then assessed for relationships between all of the above-mentioned predictor variables versus the dichotomous category of "sufficient activity." Then the variables were assessed for their relationship to the "highly active" category. Finally, the variables were examined to see if they could effectively predict the likelihood of a person being a "walker," as described above. All significant correlates were also evaluated in multivariate models, with analyses looking for confounding by the

other potential covariates/confounders if they were not univariately related to the dichotomous outcomes. As with the linear regression models, any potential confounders that altered univariately related variables' parameter coefficients in the model by $\geq$ 15% were included in the final multivariable model. All logistic regression analyses and models were evaluated with SAS System for Windows, Release 8.01 (SAS Institute Inc., Cary NC, 2000). An alpha level of < 0.05 was chosen as the significance level to determine if independent variables were related to the activity level outcomes.

CHAPTER IV

RESULTS

This chapter includes a review of the descriptive statistics, followed by an analysis of univariate relationships in both a linear regression model of total MET-min/week and three different logistic regression models with outcomes of sufficient activity, high activity, and walking. Then multivariate models were constructed for both the linear regression model and the three different logistic regression models, using the steps outlined above in the methods section.

Descriptive Statistics

Gender information was available for 852 (97%) of the participants, with 720 (84.5%) females and 132 (15.5%) males (Table 1). Ages were available for 813 (92.6%) of the participants and ranged from 25 years to 76 years, with a mean of 43.7 years (standard deviation [SD] = 6.24).

The highest education level was available for 820 (93.4%) of the participants: 120 (13.7%) had completed high school or less; 298 (33.9%) had completed some college, but did not have a degree; 32 (3.6%) had an associates degree in an occupational program; 79 (9.0%) had completed an associates degree an academic program; 169 (19.2%) had completed a bachelor's degree; 81 (9.2%) had completed a master's degree; 30 (3.4%) had a professional degree; and 11 (1.3%) had a doctoral degree (Table 2).

In preliminary analyses, education level was originally treated as a linear/continuous independent variable in the analyses and for model building. Past studies have observed that increasing education is typically associated with increasing physical activity levels (Eyler et al., 2002; Hawkins, Cockburn, Hamilton, & Mack; 2004; Kaplan, Newsom, McFarland, & Lu, 2001; King, Castrol, Wilcox, Eyler, Sallis, & Brownson, 2000; Macera, Croft, Brown, Ferguson, & Lane, 1995). However, it was noted after the model-building strategies, described previously, that the Hosmer-Lemeshow Goodness of fit for the high activity logistic regression model was not acceptable with a linear/continuous form of the variable.

Table 1

Descriptive Statistics of Demographic Variables/Potential Confounders, by Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Female	720	82.0	84.5	84.5
Male	132	15.0	15.5	100.0
Total	852	97.0	100.0	
Missing	26	3.0		
Total	878	100.0		

Table 2

Descriptive Statistics of Demographic Variables/Potential Confounders, by Education

Education Level		Frequency	Percent	Valid Percent	Cumulative Percent
1	High school or less	120	13.7	14.6	14.6
2	Some college	298	33.9	36.3	51.0
3	Associates degree (occupational program)	32	3.6	3.9	54.9
4	Associates degree (academic)	79	9.0	9.6	64.5
5	Bachelor's degree	169	19.2	20.6	85.1
6	Master's degree	81	9.2	9.9	95.0
7	Professional degree	30	3.4	3.7	98.7
8	Doctoral degree	11	1.3	1.3	100.0
	Total	820	93.4	100.0	
Missing		58	6.6		
Total		878	100.0		

Further analysis of these data disclosed that within this population, a linear trend of increasing education correlating with increasing activity did not necessarily uniformly apply. Participants in categories 7 (professional degree) and 8 (doctoral degree) always tended to be more physically active in the models than category 1 (high school or less) participants. On

the other hand, categories 2 through 6 (some college, associates degree/occupational, associates degree/academic, bachelor's degree, and master's degree) participants often were less physically active than category 1 participants even though they had more education, although effects varied in different models for college and master's degree participants. Therefore, categories 7 and 8, which had smaller numbers and similar effects, were collapsed into one category, and education levels were treated as nonlinear categories for the analyses.

For the independent variables indicating proximity to a park, recreation center, or gym, the distributions are shown in Table 3. Participants were asked: "About how long would it take to get from your home to get to the **nearest** businesses or facilities listed below if you **walked** to them?" A value of "1" was assigned for 1–5 minutes, "2" for 6–10 minutes, "3" for 11–20 minutes, "4" for 21–30 minutes, and "5" for $\geq$ 31 minutes.

Table 3

Descriptive Statistics for Variables Reflecting Subjects' Proximity to Parks, Recreation Center, and Gym or Fitness Facility

	Park	**Recreation Center**	**Gym or Fitness Facility**
Valid (*n*)	846	840	845
Missing (*n*)	32	38	33
Mean	2.93	3.73	4.10
Standard deviation	1.33	1.28	1.20
Skewness	0.12	-0.60	-1.11
Range	4.00	4.00	4.00
Minimum	1.00	1.00	1.00
Maximum	5.00	5.00	5.00

For the independent variables derived by factor analysis from the questions designed to assess the streets and sidewalks in the neighborhood, Table 4 depicts the values obtained. A value of "1" indicated the respondent *strongly disagreed* with the statement, "2" indicated they *somewhat disagreed*, "3" indicated they *somewhat agreed*, and "4" indicated they *strongly agreed.*

The variables described in Table 4 were derived through principal component factor analysis with varimax orthogonal rotation. The analysis of the responses to 14 statements

yielded two factors which the different questions loaded on. Ten of the statements loaded on a factor that appeared to represent a construct of nice streets and neighborhood aesthetics, which loaded with an Eigen value of 10.01. Four of the statements loaded on a factor that appeared to represent a construct of nice sidewalks, with an Eigen value of 1.17. The Cronbach's alpha for the first factor was 0.97 and for the second factor was 0.89, indicating good reliability of the measures used to construct the composite independent variables described in Table 4.

Table 4

Descriptive Statistics for Variables Reflecting Streets and Neighborhood Aesthetics and Nice Sidewalks

	Nice Streets and Neighborhood Aesthetics	**Nice Sidewalks**
Valid (*n*)	847	844
Missing (*n*)	31	34
Mean	2.84	2.49
Standard deviation	0.45	0.74
Skewness	-0.27	-0.24
Range	2.70	3.00
Minimum	1.20	1.00
Maximum	3.90	4.00

For the 855 participants, the mean value for the continuous outcome (dependent) measure used in the linear regression models, MET-min/week, was 1,992.7, with a minimum of 0 and a maximum of 12,852. The standard deviation was 2,185, with a slightly positively (but < 2.0) value for skewness of 1.66, mostly due to the relatively high proportion of people who reported 0 MET-min/week of physical activity (see Figure 1).

Descriptive statistics for the dichotomous outcomes of *sufficiently active, highly active*, and *walker* are presented in Table 5. "Yes" and "no" responses, coded as 1 and 0, respectively, are indicated for each category, as well as the number of participants.

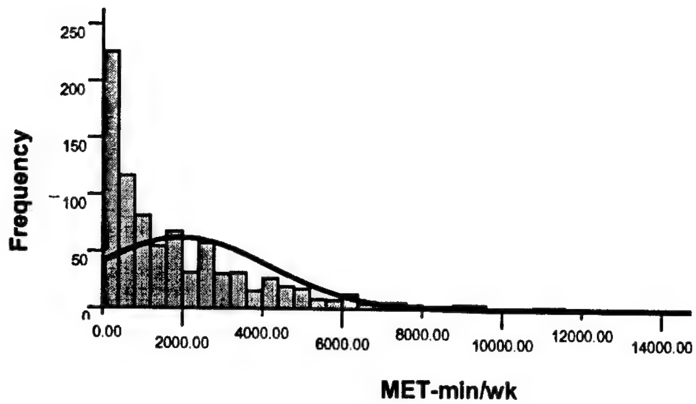

Figure 1. Frequency Histogram of Physical Activity Levels in MET-min/week

Univariate Analyses

The univariate analyses included both linear and logistic regression models. The univariate linear regression analyses assessed relationships with the linear, continuous outcome of MET-min/week. The logistic regression analyses assessed relationships with sufficient activity, high activity, and regular walking activity outcomes.

Linear Regression

The evaluation of the univariate relationships between the three primary demographic/potential confounder variables and the five hypothesized independent predictor variables for the dependent, continuous variable (MET-min/week) are illustrated in Table 6. The only statistically significant relationships were between gender and MET-min/week and between the composite variable describing nice streets and aesthetics in the neighborhood and MET-min/week. Males were significantly more likely than females to have a higher MET-min/week value. Those who had scores of higher agreement with the statements indicating they believed that they lived in neighborhoods with nicer streets and more interesting/pleasing neighborhood aesthetics were more likely than those having lower scores to have a higher MET-min/week value.

Table 5

Descriptive Statistics for Variables Reflecting Dichotomous Outcomes Analyzed in Logistic Regression Models

Level of Activity	**Frequency**	**Percent**
Sufficiently Active		
No	345	39.3
Yes	510	58.1
Subtotal	855	97.4
Missing	23	2.6
Total	878	100
Highly Active		
No	537	61.2
Yes	318	36.2
Subtotal	855	97.4
Missing	23	2.6
Total	878	100
Walker		
No (Not sufficiently active)	345	39.3
Yes	266	30.3
Subtotal	611	69.6
Missing (or sufficiently active from cause other than walking alone)	23 (244)	30.4
Total	878	100.0

Logistic Regressions

As discussed previously in the methods section, three different dichotomous outcome variables were looked at via logistic regression. The outcomes of *sufficiently active* and *highly active* were derived from the IPAQ coding recommendations, and the outcome of *walker* was looked at and coded to try to look at the group who met the sufficient activity criteria in the lowest intensity way: by walking 5 days/week for 30 minutes/day compared to the group who did not meet any of the sufficiently active criteria. For all of the logistic regression/dichotomous outcomes, the candidate independent variables were treated as linear/continuous except for gender and education, which were used as categorical variables,

Table 6

Univariate Linear Relationships between Independent Variables and Continuous Outcome—MET-min/week

Independent Variable	**Parameter Estimate**	**SE**	**Standardized Estimate**	**F**	***p*-value**
Gender	495	209	.82	5.63	.018
Age	-6	12	.017	.22	.64
Education (all levels)				1.39	.21
Some college / ≤ High School (HS)	24	212	.005		
Associates degree—occupational / ≤ HS	-698	427	-0.060		
Associates degree—academic / ≤ HS	-259	299	-0.034		
Bachelors degree / ≤ HS	-440	240	-0.080		
Masters degree / < HS	-94	299	-0.013		
Professional or doctoral degree vs. HS or less	175	385	.017		
Nice streets/aesthetics	643	166	.130	15.04	.0001
Nice sidewalks	87	102	.030	.74	.39
Park proximity	-45	56	.027	.62	.43
Recreation center proximity	-60	59	.035	1.03	.31
Gym or fitness center proximity	-7	63	.004	.01	.91

as discussed previously. The other potential independent variables, except the composite variables derived from factor analysis (the nice streets/aesthetics variable and the nice sidewalks variables), were also looked at as categorical variables. No differences were noted in which variables were significantly univariately associated with the dichotomous outcomes when they were looked at as categorical variables. Therefore, all analyses reported herein treated all of the other independent variables as continuous.

Table 7 shows the univariate relationships between the same potential predictor covariates assessed in the linear regression models and the outcome of sufficiently active. As in the linear regression analysis, gender and the nice streets/aesthetic variables were significantly associated with being sufficiently active. In these crude analyses, the odds were

that men were approximately twice (2.23) more likely to be sufficiently active than women (95% confidence interval [CI]: 1.46–3.40; *p*-value: 0.0002).

For every incremental increase of one (1) in the composite variable reflecting increasing agreement with statements indicating the subjects lived in a neighborhood with nice streets and aesthetics, the odds were 1.69 times more likely they were sufficiently active than subjects who answered one level lower on the composite variable (95% CI: 1.24–2.31; *p*-value: 0.0009).

Table 8 shows a similar logistic regression exploration of the univariate relationships between the same potential predictor covariates assessed in the linear regression models and the other logistic regression models and the outcome of highly active. In looking at this slightly different outcome, gender no longer was significantly associated with the outcome, but age was marginally associated with high activity (*p*-value: 0.061). The nice streets/aesthetics variable continued to be a statistically significant predictor of activity outcomes (*p*-value: 0.0004).

Table 9, likewise, illustrates the logistic regression exploration of the univariate relationships between the candidate predictor variables and the dichotomous outcome of being a walker. As in the model for the more broadly defined sufficiently active, although not quite as markedly, both male gender and increasing agreement with the composite nice streets/aesthetics variable statements were associated with increased odds of being a walker.

Multivariate Analyses

As with the univariate analyses, the multivariate analyses included both linear and logistic regression models. The univariate linear regression analysis assessed relationships with the linear, continuous outcome of MET-min/week. The logistic regression analyses assessed relationships with sufficient activity, high activity, and regular walking activity outcomes.

Linear Regression Model

A multivariate model to predict the continuous MET-min/week was then constructed using these data. First, a model containing the significant univariately related, independent variables of gender and nice streets and aesthetics was established. Adding the interaction

Table 7

Univariate Logistic Regression Analyses Examining Crude Associations between Potential Predictor Variables and the Dichotomous Outcome—Sufficiently Active

Independent Variable	Odds Ratio	95%Confidence Interval	*p*-value
Gender			
Female	1	-	-
Male	2.23	1.46–3.4	.0002
Age : For each 1 year increase in age	1.01	.98–1.03	.54
Education level			.23
≤ High school (HS) (reference)	1	–	–
Some college / ≤ HS	.99	.64–1.53	
Associates degree—occupational / ≤ HS	.61	.27–1.35	
Associates degree—academic / ≤ HS	.90	.51–1.62	
Bachelors degree / ≤ HS	.80	.49–1.29	
Masters degree / ≤ HS	.95	.53–1.704	
Professional or doctoral degree / ≤ HS	2.23	.97–5.12	
Nice streets/aesthetics			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	1.69	1.24–2.31	.0009
Nice sidewalks			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice sidewalks	1.07	.88–1.28	.51
Park			
For each incremental increase of 1 in answer indicating increasing distance from the park	.95	.85–1.05	.30
Recreation center			
For each incremental increase of 1 in answer indicating increasing distance from the Recreation center	.97	.87–1.08	.52
Gym/fitness center			
For each incremental increase of 1 in answer indicating increasing distance from the Gym	.96	.86–1.08	.48

Table 8

Univariate Logistic Regression Analyses Examining Crude Associations between Potential Predictor Variables and the Dichotomous Outcome—Highly Active

Independent Variable	Odds Ratio	95% Confidence Interval	*p*-value
Gender			
Female	1	–	–
Male	1.20	.82–1.76	.35
Age: For each 1 (10) year increase in age	.98 (.80)	.96–1.001	.06
Education			
≤ High school (HS) (reference)			.27
Some college / ≤ HS	1	–	–
Associates degree—occupational / ≤ HS	1.06	.68–1.64	
Associates degree—academic / ≤ HS	.63	.27–1.49	
Bachelors degree / ≤ HS	.90	.50–1.61	
Masters degree / ≤ HS	.68	.41–1.11	
Professional or doctoral degree / ≤ HS	.85	.467–1.53	
≤ High school (HS) (reference)	1.40	.68–2.88	
Nice streets/aesthetics For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	1.77	1.29–2.44	.0004
Nice sidewalks For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice sidewalks	1.05	.87–1.27	.59
Park For each incremental increase of 1 in answer indicating increasing distance from the park	.99	.89–1.10	.84
Recreation Center For each incremental increase of 1 in answer indicating increasing distance from the Recreation center	.98	.88–1.10	.77
Gym/fitness center For each incremental increase of 1 in answer indicating increasing distance from the Gym	1.0	.89–1.12	.96

Table 9

Univariate Logistic Regression Analyses Examining Crude Associations between Potential Predictor Variables and the Dichotomous Outcome—Walker

Independent Variable	Odds Ratio	95% Confidence Interval	*p*-value
Gender			
Female	1	–	–
Male	1.94	1.20–3.14	.007
Age: For each 1 (10) year increase in age	1.02		
	(1.25)	.995–1.050	.11
Education			.19
≤ High school (HS) (reference)	1	–	–
Some college / ≤ HS	.91	.55–1.51	
Associates degree—occupational / ≤ HS	.79	.33–1.90	
Associates degree—academic / ≤ HS	.87	.45–1.70	
Bachelors degree / ≤ HS	.57	.32–1.01	
Masters degree / ≤ HS	.90	.46–1.76	
Professional or doctoral degree / ≤ HS	1.92	.76–4.85	
Nice streets/aesthetics			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	1.62	1.13–2.32	.0087
Nice sidewalks			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice sidewalks	1.13	.91–1.41	.28
Park			
For each incremental increase of 1 in answer indicating increasing distance from the park	.98	.87–1.11	.77
Recreation Center			
For each incremental increase of 1 in answer indicating increasing distance from the recreation center	.98	.86–1.11	.69
Gym/fitness center			
For each incremental increase of 1 in answer indicating increasing distance from the Gym	.98	.85–1.11	.71

term of [gender * nice_streets] showed the interaction was significant, so was also included in the model. Then the other potential confounders/covariates were added into the model individually to see if any of them altered the parameter estimates by > 15%. None of them significantly altered the primary predictor variables, so were not included in the final model. Table 10 shows the data for the final multivariate model. Even though the overall model was highly statistically significant (*p*-value < .0001), the r^2 value of 0.033 indicates that just a little over 3% of the total variance in MET-min/week could be explained by this model.

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Table 10

Final Multivariable Linear Regression Model Predicting Activity in MET-min/week Based on Gender, the Composite Variable for Nice Streets/Aesthetics, and Including the Interaction between Gender and the Nice Streets/Aesthetics Variable

Characteristic	Estimated Coefficient	SE	Standardized Coefficient	F	*p*-value
Gender					
Female = 0					
Male = 1	3587	1274	.59	2.82	0.0050
Nice Streets/Aesthetics For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	872	184	.18	4.74	≤ 0.0001
Interaction [nice streets-aesthetics * gender]	-1097	452	-.51	2.43	0.015

Note: r^2 = 0.033 and overall *p*-value for model < 0.0001

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Figure 2 illustrates the effect the interaction has on MET-min/week by showing the plots for each sex at different levels of the nice streets/aesthetics variable; the effect was predicted by the multivariable linear regression model shown in Table 10. For females, as the composite variable reflecting increasing agreement that the subject lived in a neighborhood with nice streets and aesthetics increased, so did the total activity as measured in MET-min/week. However, for males, the trend appeared to be exactly the opposite: as the composite variable reflecting increasing agreement that the subject lived in a neighborhood

with nice streets and aesthetics increased, the total activity as measured in MET-min/week decreased.

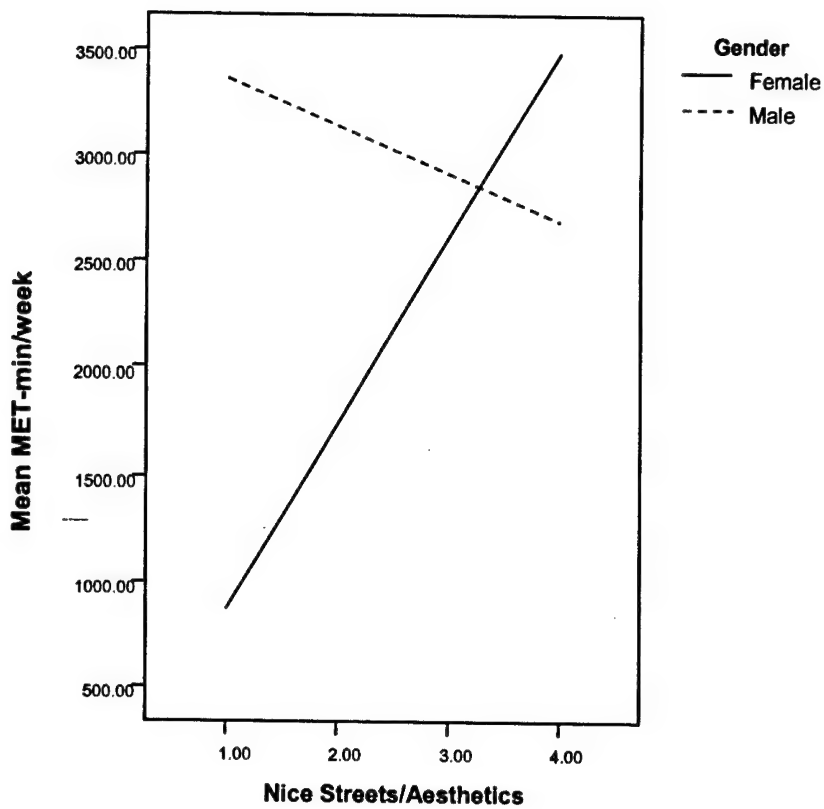

Figure 2. Total Activity in Mean MET-min/week for Different Levels of Nice Streets/Aesthetics by Gender

Logistic Regression Models

In constructing logistic regression multivariable models that might effectively predict sufficient activity, the two variables—gender and the nice streets/aesthetics—that were univariately related to sufficient activity were first entered into the model. The interaction term of [gender * nice_streets] was assessed and found to not add significantly to the model. Then the other potential confounders/covariates were added serially to the model to see if any

changed the parameters for gender or the nice streets variables by > 15%. Education changed the estimate for nice streets (by 22.8%), so the final multivariable to predict sufficient activity (outlined in Table 11) included gender, the composite nice streets variable, and education.

Table 11

Final Multivariable Logistic Regression Model Predicting Sufficient Activity Based on Gender, Education, and the Composite Variable for Nice Streets and Aesthetics

Independent Variable	**Odds Ratio**	**95% Confidence Interval**	***p*-value**
Gender			
Female	1	–	–
Male	2.24	1.44–3.49	.0003
Education			.14
≤ High school (HS) (reference)	1	–	–
Some college / ≤ HS	.96	.61–1.52	
Associates degree—occupational / ≤ HS	.61	.27–1.39	
Associates degree—academic / ≤ HS	.88	.48–1.62	
Bachelors degree / ≤ HS	.68	.41–1.13	
Masters degree / ≤ HS	.83	.45–1.52	
Professional or doctoral degree / ≤ HS	2.22	.92–5.34	
Nice streets/aesthetics			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	2.08	1.47–2.94	< .0001

Note: Hosmer-Lemeshow GOF statistic = .29 and > .10 indicates acceptable fit; overall *p*-value for model was < .0001

Based on this model, adjusting for education and gender, subjects who answered one level higher (indicating increasing agreement with the assessment they lived in a neighborhood with nice streets and aesthetics) had approximately two times higher odds (2.08=OR; 95% CI: 1.47–2.94; *p*-value < 0.0001) of being sufficiently active than their

counterparts who answered at the lower level of agreement. Also of note, adjusting for education and the nice streets/aesthetics variable, men had more than two times higher odds (OR = 2.24) of being sufficiently active than women (95% CI: 1.44–3.49; *p*-value: .0001).

Table 12 likewise shows the results for the final multivariable model predicting high activity. The univariately significantly related variables of age and nice streets/aesthetics were placed in the model and the interaction term of [age * nice streets] was added and noted to not be significant in the model. Then the other potential confounders/covariates were added to the model one at a time to see if they changed the parameter estimates for age or nice streets by >15%. Education level and the nice sidewalk variables appeared to confound the primary variables' relationships by these criteria, so they were also incorporated into the final model. Adjusting for age, education, and the nice sidewalks variable, people who answered one level higher, indicating increasing agreement with the assessment they lived in a neighborhood with nice streets/aesthetics had more than two times higher odds (OR = 2.37; 95% CI: 1.60–3.53 ; *p*-value < .0001) of being sufficiently active than their counterparts who answered at the lower level of agreement.

Adjusting for the other variables in the model, age was also a significant predictor of high activity, with every 10-year increase in age leading to a 26% decrease in the odds of being highly active compared to younger people (95% CI: 0.57–0.97; *p*-value .03). Also potentially of interest in this model, although not quite statistically significant, as people agreed more with the statements describing their sidewalks as nice, they actually appeared somewhat less likely to be highly active.

Finally, Table 13 describes the associations derived from construction of a relevant model assessing whether walkers had different associations than insufficiently active participants. Following a process similar to that pursued in developing the multivariable models for sufficient activity and high activity, a model similar to that for sufficiently active was arrived at with increasing agreement on the nice streets/aesthetics composite variable and male gender both being associated with increased odds of being a walker when adjusted for each other and education level.

Table 12

Final Multivariable Logistic Regression Model Predicting High Activity Based on Age, Education, and the Composite Variables for Nice Streets/Aesthetics and Nice Sidewalks

Independent Variables	**Odds Ratio**	**95% Confidence Interval**	***p*-value**
Age		0.95–0.997	
For each 1 (10) year increase in age	.97 (.74)	(0.57–0.97)	.03
Education			.29
≤ High school (HS) (reference)	1.0	–	–
Some college / ≤ HS	1.22	.75–1.97	
Associates degree—occupational / ≤ HS	.69	.27–1.73	
Associates degree—academic / ≤ HS	1.06	.56–2.00	
Bachelors degree / ≤ HS	.73	.42–1.27	
Masters degree / ≤ HS	.93	.48–1.79	
Professional or doctoral degree / ≤ HS	1.41	.61–3.25	
Nice streets/aesthetics			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	2.37	1.60–3.53	< .0001
Nice sidewalks			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice sidewalks	.81	.65–1.02	.08

Note: Hosmer-Lemeshow GOF statistic = 0.20 (>0.10 indicates acceptable fit) and overall *p*-value for model = .0005; CI = confidence interval for odds ratio (OR)

Table 13

Final Multivariable Logistic Regression Model Predicting Walking Based on Gender, Education Level, and the Composite Variable for Nice Streets and Aesthetics

Independent Variable	**Odds Ratio**	**95% Confidence Interval**	***p*-value**
Gender			
Female	1.0	–	–
Male	1.90	1.14–3.16	.013
Education			.091
≤ High school (HS) (reference)	1.0	–	–
Some college / ≤ HS	.89	.53–1.51	
Associates degree—occupational / ≤ HS	.76	.31–1.85	
Associates degree—academic / ≤ HS	.84	.42–1.68	
Bachelors degree / ≤ HS	.48	.26–0.89	
Masters degree / ≤ HS	.76	.38–1.54	
Professional or doctoral degree / ≤ HS	1.85	.69–4.92	
Nice Streets/Aesthetics			
For each incremental increase of 1 in composite variable reflecting increasing agreement that subject lives in a neighborhood with nice streets and aesthetics	2.08	1.39–3.12	.0004

Note: Hosmer-Lemeshow GOF statistic = 0.63; > 0.10 indicates acceptable fit; the overall *p*-value for the model = .0005.

CHAPTER V

DISCUSSION

This study, like the literature to date, provides intriguing, if still sometimes confusing, and mixed support for the importance of the physical environment in promoting physical activity. There were no statistically significant associations between proximity to the three hypothesized and discretely assessed parks, recreation centers, and gymnasiums and physical activity outcomes. There was, however, a consistent, albeit low magnitude, association between the composite variable of perceived neighborhood and aesthetics characteristics and total MET-min/week, sufficient activity, walking, and high activity. The data from this study also demonstrated significant associations with physical activity and/or confounding of environment-physical activity level relationships by demographic variables including age, gender, and level of education.

Perhaps the most interesting and potentially useful finding from this study was the repeatedly noted association of the composite variable for nice streets and neighborhood aesthetics with physical activity levels. It was associated with total MET-min/week in a multivariable linear regression model adjusted for gender, and the interaction between gender and the nice streets/neighborhood aesthetics composite variable, with a high level of statistical significance ($p < 0.0001$). Although significant, the r^2 value of 0.033 shows the overall model was only able to explain 3.3% of the variance in total self-reported physical activity levels. However, if the important parts of this variable's ability to influence physical activity levels can be further distilled in future studies and inexpensively implemented on a larger population level, it may indeed have important public health benefits in the battle against sedentary lifestyles and obesity.

Of note from the factor analysis piece of this study was the interesting result that two questions which implied hilly environments, one which subjectively gauged the neighborhood as difficult to walk or bicycle in and one which indicated the environment limited the number of routes to get from place to place, loaded on the nice streets/aesthetics factor. This factor otherwise incorporated questions that emphasized the more subjectively

pleasing aspects of having views and landscapes, which would be attributable to hilly neighborhoods. Previous studies (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; King et al., 2000) have also noted a possibly counterintuitive relationship between hills and increased physical activity. One might suppose that hilly environments, which make walking or biking a little more arduous, would be related to lower activity levels. However, it seems they may generally have exactly the opposite effect. Perhaps the view associated with hills or the sense of accomplishment in making it to the top of a hill prompt people to walk more when they are present. This study would suggest further exploration into whether hills and other aesthetically pleasing environments, especially in women given the interaction discovered in the multivariable linear regression model, promote more physical activity.

In a multivariable logistic regression model to predict sufficient activity adjusted for age and gender, participants who answered one level higher on the agreement scale for the composite variable—indicating their neighborhood had nice streets/aesthetics—were 2.081 times more likely (95% CI: 1.47–2.94; *p*-value: < .0001) to be sufficiently active than those who had one level lower agreement on the composite variable scale. Likewise, in a multivariable logistic regression model to predict high activity adjusted for age, education, and the nice sidewalks composite variable, participants who answered one level higher on the agreement scale for the composite variable—indicating their neighborhood had nice streets/aesthetics—had 2.37 higher odds (95% CI: 1.60–3.53; *p*-value: < .0001) that they were sufficiently active than those who had one level lower agreement on the composite variable scale. The relationship between nice streets/aesthetics and whether people walked at the lowest recommended levels to meet the sufficiently active criteria was also noted. Those who walked sufficiently, compared to those who did not meet the criteria for sufficient activity, had 2.08 times higher odds (95% CI: 1.39–3.12; *p*-value: .0004) of having one level higher agreement on the composite nice streets/aesthetics variable.

Another consistent finding in this study, which replicates information from many other studies (Brownson et al., 2000; Hawkins et al., 2004; Kaplan et al., 2001; King et al., 2000; Trost, Owen et al., 2002; Trost, Pate et al., 2002), was the ability of demographic variables to confound or predict physical activity-environmental relationships. The demographic variables used and assessed in this study were gender, age, and level of education. The literature cited above indicated a consistent replicated pattern of increasing

age, female gender, and lower education levels as associated with lower levels of physical activity. In the current study, female gender was significantly associated with lower total activity in both a crude/univariate linear regression model (Table 6) and in a multivariable adjusted model (Table 10). Likewise, it was associated in crude and adjusted logistic regression analyses with lower rates of sufficient activity (Tables 7 and 11) and walking (Tables 9 and 13).

Age was marginally univariately associated with the likelihood of being highly active (*p*-value: .06). Further, in the multivariable model adjusted for education, nice streets/aesthetics, and nice sidewalks, increasing age was significantly and inversely associated with the likelihood of being highly active, as has been noted in most of the literature. Subjects who were 10 years older had approximately 26% lower odds of being highly active than younger subjects (*p*-value: .03).

Although education level changed/confounded the relationships between univariately associated variables in all three logistic regression models, it did not have a clear overall statistically significant univariate relationship to any of the physical activity outcomes in any of the models. However, as noted previously, its tendency to influence physical activity outcomes was not necessarily always in a consistent linear trend. In all four models, the highest education levels (doctoral or professional degrees) were associated with trends toward more activity compared to participants who had completed high school or less, but the trends were less clearly consistent between other educational categories. It could be hypothesized that those at the highest educational levels had more leisure time available to pursue physical activities, whereas the intermediately educated participants might actually have less time available for such pursuits than participants educated at the high school or less level. Investigation of such hypotheses might also be of interest to future studies.

Some of the unexpected negative results from this study included the lack of association between proximity to parks, recreation centers, or gyms to any of the physical activity outcomes examined. These variables were neither univariately associated nor confounding in any of the models. It is not entirely clear why these relationships were not demonstrable. It was initially thought in constructing this study that there would very likely be significant relationships with the walking outcome and park proximity. Likewise, it was hypothesized that proximity to gyms or fitness facilities would be correlated with high

activity. Perhaps, as previously discussed by others (Humpel et al., 2002; Sallis & Owen, 1996; Sallis et al., 1997), people's perceptions of proximity to physical activity-promoting environmental constructs are not associated with physical activity, while objective measurements of proximity to these environmental constructs are associated and will be more helpful in future studies. It could also be that the categorization of the proximity variables did not capture the important and significant relationships. Maybe it only matters if people are within 1 or 2 or 5 or 10 minutes from some facilities. Or perhaps it is more important how close some of these facilities are to school or work activities than to home, although this hypothesis was somewhat refuted by Sallis et al's (1997) previously cited study.

Strengths and Limitations

There were several strengths of this study. First and foremost, by having such a large sample size, it was perhaps possible to tease out the subtle relationship between nice streets/aesthetics and physical activity, which may lend itself to further study and eventual public health policy. Second, the study supported the Ecological Models' theoretical underpinnings that there are environmental factors that contribute to people's behaviors, including physical activity. Third, by illustrating significant further negative findings in several self-reported proximity variables, this study contributed to the literature by suggesting that many self-reported measures of the environment do not help predict physical activity levels. Fourth, this study found some of the same relationships between demographic variables gender and age that other studies have consistently found, suggesting the more novel findings may also be valid. .

There were several limitations of this study. Foremost, because the study was cross-sectional in nature, no temporal relationships were assured. Did people who had higher scores in agreement on the composite variable, which indicated their neighborhood had nice streets/aesthetics, choose to be more physically active because of these characteristics? Or do people who would choose to be more active anyway choose to live in neighborhoods with nice streets/aesthetics? Likewise, perhaps people who are more physically active are more likely to notice the nice streets/aesthetics (hills?) in their neighborhoods than their neighbors who do not walk or exercise in the environment regularly. Without temporality, clearly no causal inferences are justified. A second limitation was that there was likely a significant

selection bias, as only those parents who were interested enough in the concept of introducing their children to a study focusing on healthy lifestyles volunteered to participate in this study. This selection bias clearly limited the external validity of these results. However, these self-selection effects may have been mitigated somewhat by the fact that 100% of the parents who showed up with their children did participate in this study.

Third, as with any questionnaire-based study, there were likely to be different types of information bias, including likely recall and reporting biases. Fourth, the complexity of data processing/cleaning for the IPAQ instrument speaks to the high potential for misclassification biases in characterizations of subjects' activity level. Clearly, many people completing the questionnaire misunderstood how to answer correctly to reflect their physical activity levels. Both of these limitations are and will likely continue to be addressed in future studies by using more objective measurements of both environmental variables, such as GIS coding of the environment and more objective measures of physical activity variables through the use of accelerometer and global position system (GPS) devices.

Future Research

In the future, it will continue to be important to try to explore and improve survey-based instruments. Evidence supporting the Ecological Models is still relatively nascent, and a great deal more exploratory work still seems appropriate to tease out what factors in the environment public health policy should really work to mitigate our obesity and sedentary lifestyle epidemic.

Survey-based instruments have the advantage of being far cheaper than GIS codings and accelerometers, thus potentially allowing far more hypotheses to be explored than GIS and accelerometer studies alone would. As has been previously discussed in this presentation and other studies (Kirtland et al., 2003; Sallis & Owen, 1996), surveyed perceptions of the environment do not necessarily correlate with the actual physical environment. We may find it much more cost-effective and useful to target perceptions of the physical environment to promote physical activity than to target actual physical environmental changes. It is also very expensive to build hills in everybody's environment, but helping people change their thought processes or attitudes regarding their environment and physical activity may not require moving mountains!

That said, ultimately once the most useful environmental and/or perceptual elements for promoting physical activity have been fully delineated, the strongest studies supporting the Ecological Models will involve objective measurements of both the environment and physical activity with multiple comparison groups. Ideally they would also involve longitudinal studies of groups of randomized participants/residents. However, as previously noted (Saelens, Sallis, & Frank, 2003), the logistics and expenses of such projects are significant barriers to scientific study on any large scale. Absent the random assignment, however, valid data is also eventually likely to come out of prospective comparison studies of physical activity levels in neighborhoods with markedly different environmental characteristics along the lines of the previously mentioned Navy study (Linenger et al., 1991). Such studies are not likely to be inexpensive either, but as the important perceptual and environmental contributors to increased physical activity are increasingly discerned, they can help us target public policy interventions that are most likely to effectively combat the obesity and sedentary lifestyle epidemics.

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APPENDIX A

SURVEY OF STORES, FACILITIES, AND OTHER THINGS IN YOUR NEIGHBORHOOD

APPENDIX B

SURVEY OF WALKING AND BICYCLING IN YOUR NEIGHBORHOOD

APPENDIX C

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ) SHORT FORM

ABSTRACT

ABSTRACT

Obesity and its corollary, inadequate physical activity, are widely recognized as epidemic problems in the United States. Many different approaches have been pursued to address the lack of adequate physical activity, but none have been uniformly successful. Despite widespread publicity and public health attention throughout the 1990s, rates of adherence to widely promoted recommended physical activity levels remained at only about 25% throughout the 1990s. One theoretical approach to this problem involves exploration of Ecological Models, which posit that people who live in environments more conducive to physical activity will be more likely to be physically active.

This cross-sectional observational study of data previously collected from parents of adolescents involved in an intervention trial was designed to investigate whether the parents were more likely to be physically active if they reported living closer to parks, bicycle paths, and fitness centers. Composite variables that reflected nice streets/aesthetics and nice sidewalks were also created from questionnaires by using factor analysis. After univariate relationships were assessed, a multivariable linear regression and three logistic regression models were constructed with the appropriately modeled confounders of age, gender, and education level to see if the environmental variables were associated with physical activity as reported on a validated scale, the International Physical Activity Questionnaire. Relationships with total MET-minutes/week and the dichotomous outcomes of sufficient activity, high activity, and regular walking were assessed.

It was hypothesized that subjects who reported living closer to activity-promoting physical environments would be more physically active. There were statistically significant relationships between the composite variable reflecting nice streets/aesthetics and more physical activity in all four models (p-value $\leq .0004$ in all four). In the logistic regression model, there was also evidence of a statistically significant (p-value .015) interaction of the composite variable of nice streets/aesthetics by gender. Women with higher scores on the nice streets/aesthetics composite variable tended to be more physically active, while men tended to be less physically active. Prospective or controlled studies confirming these associations and others examining Ecological Models will be expensive, but could have

profound implications on how new developments and urban redevelopments should be structured to improve physical activity and decrease obesity.

ABSTRACT OF THE THESIS

Relationship between Self-Reported Physical Activity
and Environmental Variables in
Parents of Adolescents
by
Daniel G. Burnett
Master in Public Health
San Diego State University, Spring 2004

Obesity and its corollary, inadequate physical activity, are widely recognized as epidemic problems in the United States. Many different approaches have been pursued to address the lack of adequate physical activity, but none have been uniformly successful. Despite widespread publicity and public health attention throughout the 1990s, rates of adherence to widely promoted recommended physical activity levels remained at only about 25% throughout the 1990s. One theoretical approach to this problem involves exploration of Ecological Models, which posit that people who live in environments more conducive to physical activity will be more likely to be physically active.

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STORES, FACILITIES, AND OTHER THINGS IN YOUR NEIGHBORHOOD

About how long would it take to get from your home to get to the **nearest** businesses or facilities listed below if you **walked** to them? (PLEASE CIRCLE ONE NUMBER FOR EACH BUSINESS OR FACILITY)

	1-5 min	6-10 min	11-20 min	21-30 min	31+ min
1. Convenience/small grocery store	1	2	3	4	5
2. Supermarket	1	2	3	4	5
3. Hardware store	1	2	3	4	5
4. Fruit/vegetable market	1	2	3	4	5
5. Laundry/dry cleaners	1	2	3	4	5
6. Clothing store	1	2	3	4	5
7. Other Stores (e.g. florist)	1	2	3	4	5
8. Post office	1	2	3	4	5
9. Library	1	2	3	4	5
10. Elementary school	1	2	3	4	5
11. Other schools	1	2	3	4	5
12. Your job	1	2	3	4	5
13. Bus or trolley stop	1	2	3	4	5
14. Park	1	2	3	4	5
15. Recreation center	1	2	3	4	5
16. Gym or fitness facility	1	2	3	4	5

WALKING AND BICYCLING IN YOUR NEIGHBORHOOD

PLEASE CIRCLE THE ANSWER THAT BEST APPLIES TO YOU AND YOUR NEIGHBORHOOD.

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1. The streets in my neighborhood are hilly making my neighborhood difficult to walk or bicycle in.	1	2	3	4
2. There are many canyons/hillsides in my neighborhood that limit the number of routes for getting from place to place.	1	2	3	4
3. There are sidewalks on most of the streets in my neighborhood.	1	2	3	4
4. The sidewalks in my neighborhood are well maintained (consider cracks, evenness).	1	2	3	4
5. There are bicycle or pedestrian trails in or near my neighborhood that are easily accessible.	1	2	3	4
6. Sidewalks are separated from the road/traffic in my neighborhood by parked cars.	1	2	3	4
7. There is a grass/dirt strip that separates the streets from the sidewalks in my neighborhood.	1	2	3	4
8. It is safe to ride a bike in or near my neighborhood.	1	2	3	4

NEIGHBORHOOD SURROUNDINGS

PLEASE CIRCLE THE ANSWER THAT BEST APPLIES TO YOU AND YOUR NEIGHBORHOOD.

	strongly disagree	somewhat disagree	somewhat agree	strongly agree
1. There are trees along the streets in my neighborhood	1	2	3	4
2. There is tree cover or shade along the sidewalks in my neighborhood.	1	2	3	4
3. There are many interesting things to look at while walking in my neighborhood.	1	2	3	4
4. My neighborhood is generally free from litter.	1	2	3	4
5. There are many attractive natural sights in my neighborhood (such as landscaping, views).	1	2	3	4
6. There are attractive buildings/homes in my neighborhood.	1	2	3	4

Questions which loaded on the 2nd factor are enclosed within boxes; All other questions loaded on the 1st factor.

PHYSICAL ACTIVITY

In answering the following questions,
- **vigorous physical activities refer to activities that take hard physical effort and make you breath much harder than normal**
- **moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.**

1. During the last 7 days, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling? Think about only those physical activities that you did for at least 10 minutes at a time.

   ________ days per week ⇨ How much time in total did you usually spend on one of those days doing vigorous physical activities?

   or ____ hours ____ minutes

   None

   ⇩

2. Again think only about those physical activities that you did for at least 10 minutes at a time. During the last 7 days on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   ________ days per week ⇨ How much time in total did you usually spend on one of those days doing moderate physical activities?

   or ____ hours ____ minutes

   None

   ⇩

3. During the last 7 days, on how many days did you **walk** for at least 10 minutes at a time? This includes walking at work and at home, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise, or leisure.

   ________ days per week ⇨ How much time in total did you usually spend walking on one of those days?

   or ____ hours ____ minutes

   None

   ⇩

4. The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading, traveling on a bus or sitting or lying down to watch television.

   During the last 7 days, how much time in total did you usually spend sitting on a **week day**?

   ____ hours ____ minutes